Uncertainties in EPA Estimates of Cancer Risk from Environmental Exposure to Radionuclides

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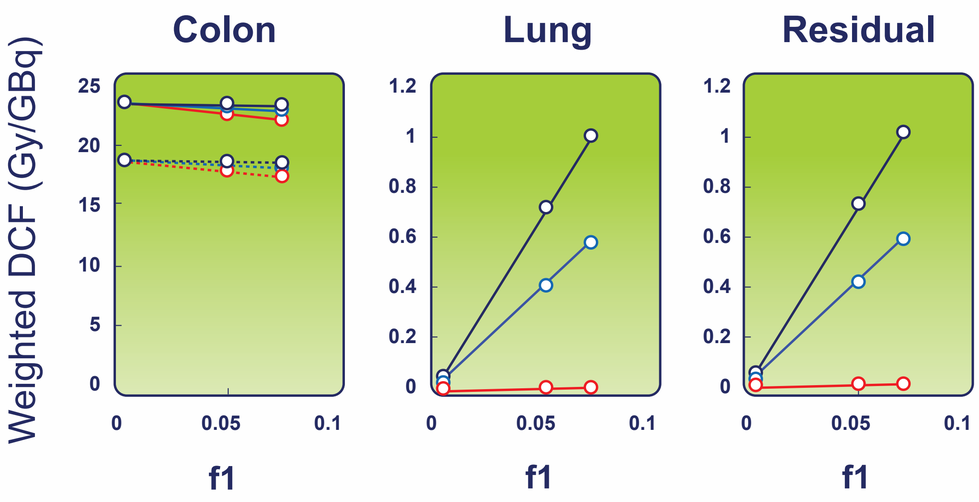
BACKGROUND

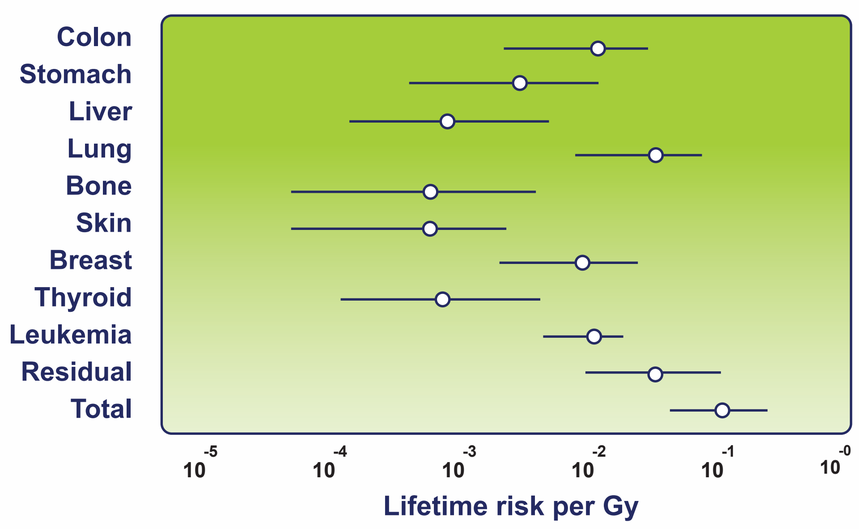
- EPA's Federal Guidance Report (FGR) 13 provides risk coefficients for ingestion, inhalation, and external exposure to more than 800 radionuclides.
- Risk coefficients for ingestion or inhalation of a radionuclide are estimates, for an average member of the public, of the probability of radiogenic cancer mortality or morbidity per unit activity taken into the body.
- Risk coefficients are based on intake assumptions, biokinetic models, models for calculating dose to radiosensitive tissues from radiation originating in the body, and models for age-specific excess cancer rates per unit dose to these tissues.
- In this report, we characterize uncertainties for the risk coefficients in FGR 13. Uncertainty intervals were determined using a Monte Carlo simulation.
- The uncertainty analysis was based on a simplified model for calculating risk. Age dependencies for calculating dose and risk per unit dose were not accounted for.
- Uncertainties associated with dose per unit activity intake and risk per unit dose are illustrated below.

Dose Per Unit Activity Ingested for Ru-106



The absorbed dose (Gy) per unit activity depends on alternative choices for: f1 (the fraction of radionuclide reaching the stomach that would be absorbed to blood during passage through the gastrointestinal tract without radiological decay); systemic biokinetic models (denoted by the different colors – describe the distribution and translocation of a substance after its absorption or injection into the systemic circulation); dosimetric models (solid vs. dashed lines – relates absorbed doses in target tissues to radioactivity in source regions).

Risk per Unit Dose



Uncertainty intervals are shown for risk per unit dose (Gy) derived from results of an expert elicitation. Nine experts were questioned about the lifetime probability of a radiation-induced cancer death from 1 Gy of acute whole-body gamma radiation (Nuclear Regulatory Commission and Commission of European Communities 1997). Uncertainty intervals are somewhat wider for doses received at lower dose rates.

RESULTS

- For ingestion, the ratio of the 95% to 5% values of the uncertainty intervals is:
  - **< 15 for ~ 25 % of the radionuclides, *e.g. H-3, Cs-137, Sr-90;***
  - **< 35 for ~ 75 % of the radionuclides, *e.g. Co-60, Ru-106; and***
  - **> 150 for ~ 3 % of the radionuclides, *e.g. Gd-148.***
- The corresponding ratios tend to be slightly smaller for inhalation *(less uncertainty).*
- Uncertainty associated with risk per unit dose is greater than uncertainty associated with dose per unit intake for most radionuclides.
- Uncertainty is smallest for radionuclides that
  - **are fairly uniformly distributed in the body; *and***
  - **emit high-energy gamma rays.**

COMMENTS

- May not be an appropriate method for radionuclides with strong age dependency in both dose per unit intake and risk per unit dose (e.g., I-131).
- Method does not fully account for uncertainties associated with the assumption that excess risk is proportional to dose.
- The National Academy of Sciences completed a major study on the health effects from low levels of radiation (2006). EPA plans to update its projections of radiogenic cancer risks.

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